

**MAC TO VAX CONNECTIVITY -
HEARTRATE SPECTRAL ANALYSIS SYSTEM**

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ABSTRACT

The heart rate Spectral Analysis System (SAS) acquires and analyzes in real-time the Space Shuttle on board experiments electrocardiograph (EKG) signals, calculates the heartrate, and applies a Fast Fourier Transformation (FFT) on the heart rate. The system also calculates other statistical parameters such as the 'mean heart rate' over specific time period and a heart rate histogram. This SAS is used by NASA Principal Investigators as a research tool to determine the effects of weightlessness on the human cardiovascular system. This is also used to determine if Lower Body Negative Pressure (LBNP) is an effective countermeasure to the orthostatic intolerance experienced by astronauts upon return to normal gravity. In microgravity, astronauts perform the LBNP experiment within the middeck of the Space Shuttle. This experiment data is downlinked by the orbiter telemetry system, then processed and analyzed in real-time by the integrated Life Sciences Data Acquisition (LSDS) - Spectral Analysis System. The data system is integrated within the framework of two different computer systems, VAX and Macintosh (Mac), using the networking infrastructure to assist the investigators in further understanding the most complex machine on Earth - the human body.

INTRODUCTION

Real-time data analysis has become popular among scientists and researchers as computers become faster and more cost effective. The Spectral Analysis System (SAS) is designed to perform real-time data analysis on microgravity- based life sciences experiments. Over the years, in the life sciences area, scientists have thought of microgravity as a source of physiological difficulties. To study the astronauts adaptation and the after-effect in normal gravity when they return to the earth, the SAS can be a useful tool.

In the past, data were acquired in real-time, but processed and analyzed postflight. The primary focus in real-time was to view the very essential ancillary data during a Space Shuttle mission. The scientist has to retrieve the science data from the NASA data facility to be able to work in their lab and perform further analysis, filtering, digital signal processing and statistical algorithms are needed to study the effects of microgravity and radiation on living organisms.

The SAS is designed to run in real-time on an Apple Macintosh IIfx based desktop computer system. The SAS is capable of acquiring analog EKG samples to perform a realtime FFT output of the heart rate using the off-the-shelf LabVIEW™ 2 software package. The analog signal produced by the LSDS is interfaced into an analog acquisition (NB MIO-16) and Direct Memory Access (DMA) board on the SAS Macintosh. This subsystem acquires data at a rate of 500 samples per second using the LabVIEW™ software and the acquisition hardware. The SAS was used extensively in conjunction with the Life Sciences Data System for analyzing the data in the Science Monitoring Area (SMA) at Johnson Space Center in realtime during the STS 43, STS 44, STS 49, USML and SL-J missions.

The intent of this paper is to introduce the underlying usage of a desktop system like Macintosh incorporating with network interface can help to understand the connectivity issues to retrieve data for real-time analysis.

THE MAC TO VAX CONNECTIVITY

The primary computer systems for the LSDS are VAX computers, which are directly interfaced with the Shuttle downlink telemetry system. The Machintosh computer is used as a backend desktop system for the SMA to aide the investigator in studying the life sciences microgravity-based experiment

data. The VAX and the Mac connectivity is established via the IEEE 802.3 Ethernet, using the DECnet as a protocol for software communication.

The LSDS VAX system acquires, archives and processes the high rate raw downlink multiplexed telemetry data. This data is acquired in realtime and is demultiplexed and extracted by the VAX system for the distribution over the Ethernet network to the desktop system. The Macintosh system uses the 'DECnet for Macintosh' for logical link to access the converted data from the VAX. The extracted data is in a digital form, so further processing is used by the Macintosh computer to convert the data into its original form (which is analog for EKG) to perform the FFT output of the heart rate. Figure 1 shows the overall data flow.

The overall design environment provides a consistent user interface by the Macintosh graphics user interface. The SAS data interchange standards is based on consultative Committee for Space Data Systems (CCSDS) packet standard using the DECnet as a protocol for communication link and access.

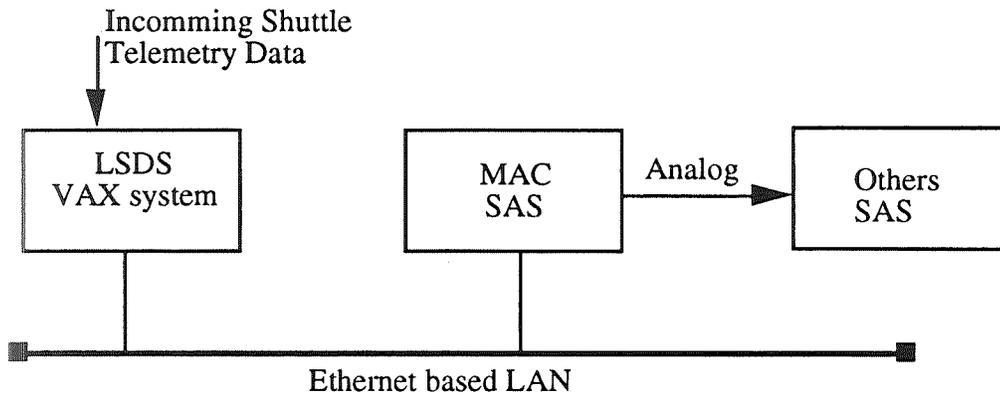


Figure 1: The overall systems data flow

Mac-DECnet Object Declaration

This section provides a sample 'C' program to declare an object for logical link within the Macintosh using DECnet protocol to connect to a VAX system for accessing the network data and command. In this example the Macintosh application waiting for a connection request from the VAX to establish the communication link:

Sample program

```

// set up a DECnet object using DECnet
Boolean      SetupObject()
{
    short error ;
    IOParm param_blk ;
    unsigned char  buffer[3] ;
    Boolean flag = true ;

    //      if (!Control.link_flag)
    //      {
    //          describe the command to setup object
    //          buffer[0] = 2 ;

    //          object number
    //          buffer[1] = Object ;
  
```

```

        buffer[2] = 0 ;
//      DECnet data structure handle
        param_blk.ioPosOffset = (long) Control.Dec_hdl ;
//      DECnet driver reference number, obtained after opening a driver

        param_blk.ioRefNum = Control.ref_num ;
        param_blk.ioCompletion = nil ;

//      number of bytes sent to the driver in this command
        param_blk.ioReqCount = 3 ;

//      command buffer
        param_blk.ioBuffer = &buffer[0] ;

//      declare object by sending message to DECnet
        error = PBWrite((ParmBlkPtr) &param_blk, false) ;

        if (error != noErr)
        {
            ok_dialog(error_box,"DECnet Unable to Setup Object",error, nil) ;
            flag = false ;
        }
    }
    return(flag) ;
}

```

VAX-DECnet Requesting a Connection

This section describes the VAX nontransparent task-to-task DECnet communication setup, using a higher level programming. The 'FORTRAN' example here shows how to create and use a VMS mailbox for receiving network messages, including network status notifications.

```
CALL SYSS$CREMBX(MBX_CHAN,%VAL(MSG_SIZE),%VAL(BUF_SIZE),,,MBX_DESC)
```

```
CALL SYSS$ASSIGN('_NET:',CHAN,,MBX_DESC)
```

The following example provides how to declare a task in VAX enabling to process the Macintosh inbound logical link connection request:

```
!Build a Network Control Block
NCBDESC1(2) = %LOC(NCB)
```

```
CALL SYSS$QIOW(%VAL(CHAN),%VAL(IOS_ACCESS),IOSB,,,NCBDESC1,,,,)
```

The general concept implicit in DECnet-VAX task-to-task communication are covered in Guide to DECnet-VAX Networking Manual by Digital Equipment Corporation.

MACINTOSH SOFTWARE

Once the network data packet is received by the Macintosh system, the data packet is converted into analog samples using the National Instrument's NB-AO-6 board. This sample data is then passed through another National Instrument's NB-MIO-16L board using the DMA features of the National Instrument boards. The above design feature is used because the Macintosh IIfx computer do not provide any DMA - I/O capability. And also, this design allows multiple SAS subsystems for the FFT output from a single network Macintosh connection. In this concept the analog data samples are distributed to other

Macintosh systems, while a single Macintosh is connected to the LSDS VAX system, handling the connectivity and other handshakings.

The analog EKG samples are then passed through a software peak detector to find the peaks for the heart rate calculation. A circular buffer system is designed to implement the acquisition part of the SAS analysis package. Once 256 heart rate samples are collected, an FFT algorithm is run on the array of that heart rate. After the FFT magnitude, the power of different bands and HEART RATE/TIME are calculated and displayed, the next batch of sample data, which is buffered during the intensive calculation of peak detection and FFT algorithm is used to repeat the same process every 10 seconds. Figure 2 shows the data path of the FFT analysis.

The SAS application runs continuously in acquisition mode to acquire EKG signal and calculate the heart rate data from the EKG signal. The output (FFT and the histogram) can be saved as a Pict file onto the disk for further post-test analysis.

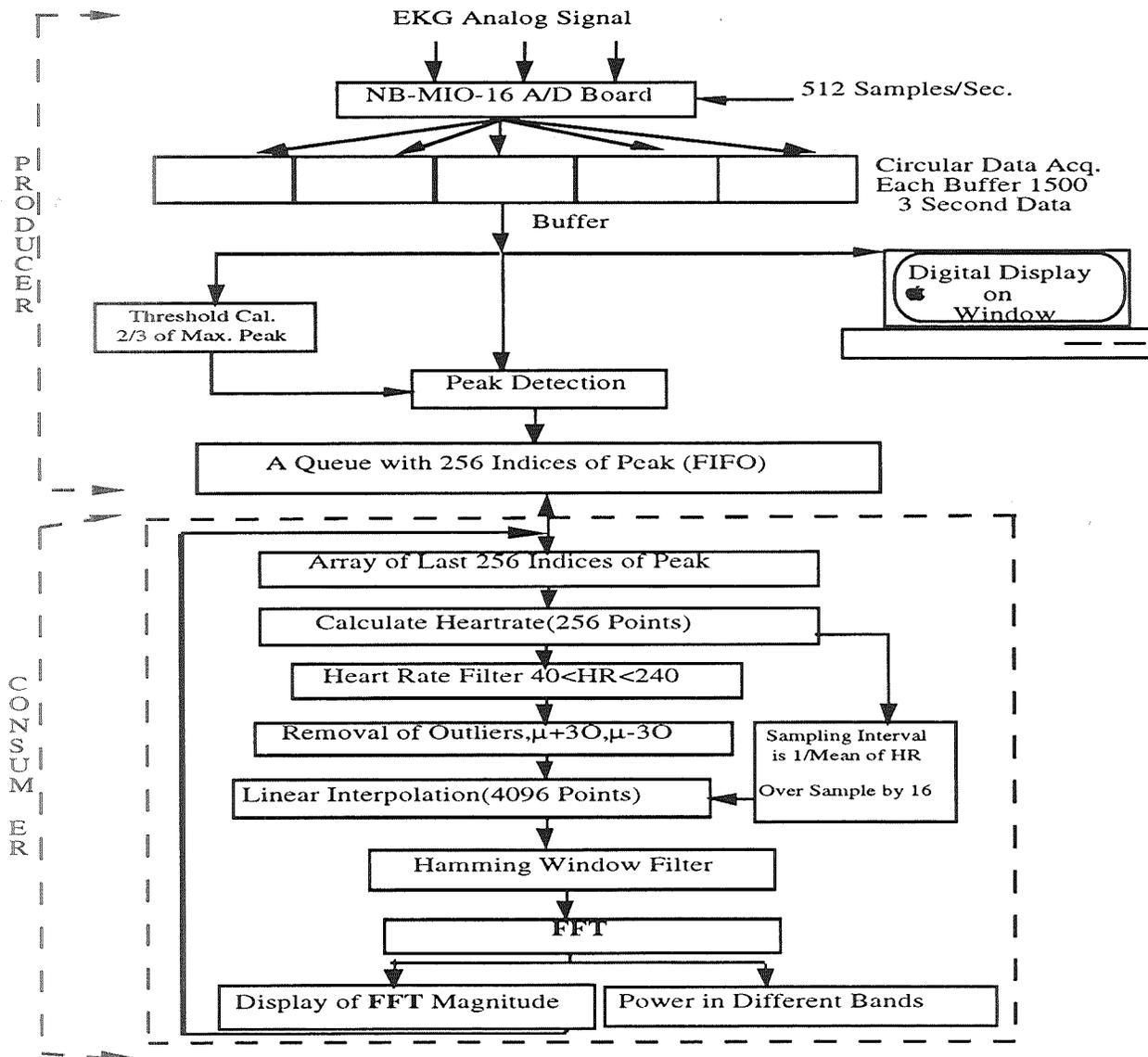


Figure 2. Block Diagram for Data Flow

SOFTWARE REQUIREMENT

LABVIEW 2 Provides the software development environment which is used to program the SAS on a Macintosh platform for data acquisition, manipulation of the acquired data, analyze and display of the acquired experiment data samples.

DECnet for Macintosh provides the network connectivity tools to access the needed data from a VAX system for analysis.

HARDWARE REQUIREMENT

Macintosh IIfx - Provides the fundamental processing platform.

Ethernet Controller Card - Provides the network connectivity.

Digital to Analog Board (NB-AO-6) - Provides the conversion of Digital data into analog samples.

Multi-functional I/O Board (NB-MIO-16L) - Provides the acquisition of analog samples.

Direct Memory Access Board (NB-DMA) - Provides the data transfer from/to I/O board with a minimum interruption and CPU usage.

ACKNOWLEDGEMENT

The Spectral Analysis System described in this paper was developed by Monazer Faruque of the General Electric Government Services, at the NASA Johnson Space Center in Houston, Texas, under a contract with the Life Sciences Project Division.

REFERENCES

1. Digital Equipment Corporation - Guide to DECnet-VAX Networking Manual
2. Digital Equipment Corporation - DEC Pathworks for Macintosh.
3. National Instrument Corporation - LabView 2 Programmers/Users Guide.
4. Robert W. Ramirez, "The FFT Fundamentals and Concepts", 1985 by Tektronix Inc. Englewood Cliffs, New Jersey 07632.